

AN INVESTIGATION ON THE COMPARISON OF THE EFFECTIVENESS OF VARIOUS NATURAL REMEDIES SUCH AS FRUITS AND VEGETABLES VERSUS ARTIFICIAL MEDICINAL ANTACIDS ON CURING HYPERACIDITY

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ABSTRACT

During a visit to my native place, I found that, natural vegetable juices are used for curing hyperacidity over there. This fascinated me, since I have always thought antacids are the only cure for hyperacidity. Hence, this investigation is based on the effectiveness of fruits and vegetables versus antacids, on curing hyperacidity.

This investigation aims to answer the research question "How does the effectiveness of various natural remedies like fruits and vegetables compare against artificial medicinal antacids when neutralizing the excess hydrochloric acid present in the stomach and curing hyperacidity?"

In order to compare the alkalizing ability of natural fruits and vegetables, a fixed volume and concentration of hydrochloric acid was titrated with juices of 1 fruit and 4 vegetables - Spinaciaoleracea, Momordicacharantia, Cucumissativus, Brassicaoleracea var. italic and Cucumismelo var. inodorus. The effectiveness of these vegetables and fruit at neutralizing hydrochloric acid was compared with the neutralizing ability of an antacid. The same volume and concentration of hydrochloric acid was titrated with the antacid solution. Eno™ antacid was chosen for this investigation since its active ingredient is sodium bicarbonate which is soluble in water.

It was found that, the antacid was more effective as a remedy for curing hyperacidity, as compared to the 5 natural remedies. Amongst the fruit and vegetables, Spinaciaoleracea was most effective at neutralizing the hydrochloric acid. It required 1.32 cm³ of the antacid solution, to neutralize the hydrochloric acid. 2.12 cm³ of the Spinaciaoleracea juice was required to neutralize the same volume and concentration of hydrochloric acid. The small difference of 0.80 cm³ proved that, Spinaciaoleracea can serve as a substitute for various antacids, since it offers other benefits to the human body, whereas antacids can have side effects on the body.

KEYWORDS: Spinaciaoleracea, Momordicacharantia, Cucumissativus, Brassicaoleracea Var. Italic and Cucumismelo var. Inodorus

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INTRODUCTION

Hyperacidity is a common medical condition in which the stomach glands produce extra hydrochloric acid.¹ This acid has a very low pH and is responsible for digesting the food present in the stomach and killing any bacteria present in the food. This is usually caused due to smoking, stress, consumption of alcohol, spicy food, non-vegetarian food etc.² In India, annually, more than 10 million people suffer from this problem³. During this

¹ "Acidity". TheHealthSite. Web. 15 Jan. 2017.

² Acid Reflux. 1st ed. Google. Web. 15 Jan. 2017.

condition, the excess hydrochloric acid rises up the esophagus and causes irritation, such as heartburn (a burning sensation in the lower part of the chest)⁴, nausea and persistent hiccups. In order to counteract these symptoms, antacids are consumed since, they are highly alkaline nature. Hence, they aid in neutralizing the excess stomach acid. Antacids are quite common since, they are easy to consume and are known to give quick results.

The idea of this topic came up, when one of my relatives suggested my father, who was suffering from hyperacidity; to consume *Momordicacharantia* (bitter gourd) juice, in order to cure the issue. This did solve the problem and fascinated me, at the same time since; I had always thought that, only antacids were capable of curing hyperacidity. This made me think if *Momordicacharantia* and other vegetables are better than medicinal antacids, at curing hyperacidity.

This has a major real life application. Antacids, being artificial, are known for curing hyperacidity and vegetables, such as *Momordicacharantia*, being natural, is also capable of curing hyperacidity. Antacids are a major component of any pharmaceutical industry. In India, the drugs make up for 20% of the global exports⁵. Hence, the focus of this investigation is to determine what is more effective, at neutralizing excess stomach acid, natural foods or artificial antacids and therefore, answer the **research question**:

How does the effectiveness of various natural remedies like fruits and vegetables compare against artificial medicinal antacids when neutralizing the excess hydrochloric acid present in the stomach and curing hyperacidity?

Below is the list of the fruit and vegetables used:

- *Spinaciaoleracea*- Spinach
- *Momordicacharantia* - Bitter Gourd
- *Cucumissativus*- Cucumber
- *Brassicaoleracea var. italica* - Broccoli
- *Cucumismelo var. inodorus* - Honeydew melon

BACKGROUND INFORMATION

Acid Reflux

The stomach secretes gastric juices. The constituents are gastric juices are hydrochloric acid, potassium chloride and sodium chloride. Hydrochloric acid is secreted by parietal cells and is the main component of the gastric juices. This acid has a low concentration (0.01 to 0.1 moles per litre), as well as a low pH (1.5 to 3.0)⁶. This makes the hydrochloric acid highly corrosive that is capable of damaging the stomach lining. Goblet cells present in the intestinal tracts secrete large amounts mucus, that forms a protective layer over the stomach lining and prevent it from getting damaged by the hydrochloric acid. Ideally, the stomach has around 20 to 100 millilitres of hydrochloric present⁷. During hyperacidity, the parietal cells secrete excess hydrochloric acid. This excess acid then rises up the esophagus. Since, the esophagus does not have any goblet cells; it doesn't have a protective mucus coating, unlike the stomach. The medical term for this condition

³Acid Reflux. 1st ed. Google. Web. 15 Jan. 2017.

⁴MacGill, Markus. "What Is Heartburn? What Causes Heartburn?". *Medical News Today*. Web. 15 Jan. 2017.

⁵"Indian Pharma Industry: Market Size, Investment, Sector Growth Report". Ibef.org. Web. 17 Jan. 2017.

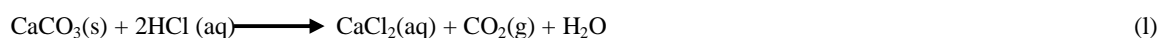
⁶Brennan, John. "Average Amount of Stomach Acid in the Human Stomach". *LIVESTRONG.COM*. Web. 15 Jan. 2017.

⁷"Stomach Acid Test: Medlineplus Medical Encyclopedia". Medlineplus.gov. Web. 18 Jan. 2017.

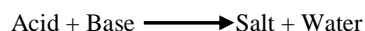
is called Acid Reflux, wherein the excess hydrochloric acid flows back into the esophagus, and irritates the esophageal lining causing painful sensations (Eg: heartburn). Frequent acid reflux problems result in a disease, called gastro esophageal reflux disease (GERD)⁸.

Antacids

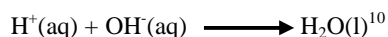
Antacids are chemical agents that neutralize the extra hydrochloric acid, present in the stomach and raise the overall pH, since they are alkaline. Antacids are generally consumed with water and they dissolve in the water, through ionic dissociation, since, water is a polar solvent, forming a solution. They have different active ingredients present in them, that are weak bases. The type of active ingredient determines the effectiveness of that particular antacid. Examples of certain active ingredients are calcium carbonate [CaCO₃], and sodium bicarbonate [NaHCO₃]. Below are the chemical reactions of each of these 2 active ingredients, reacting with hydrochloric acid:



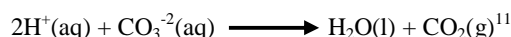
Since antacids are basic and react with acid, the above 3 chemical reactions can be generalized, as a basic neutralization reaction:



When the neutralization reaction takes place, hydrogen ions from the acid (H⁺) react with the hydroxide ions, from the base (OH⁻) to form water molecules (H₂O). This can be shown as a common ionic reaction:



When carbonate ions are present in the base (such as in CaCO₃ and NaHCO₃), reaction with the acid gives off carbon dioxide as the gas in the form of bubbles known as effervescence. Such reactions can be shown by a common ionic equation:



Hypothesis

Since, antacids are scientifically made and tested; they should be more effective at neutralizing the excess hydrochloric acid, during hyperacidity. Amongst the natural remedies, *Momordicacharantia* should be more effective and *Cucumismelo var. inodorus*, should be least effective.

Table 1: Experimental Variables

Variable	What is the Variable?	Application in Investigation
Controlled	Volume and concentration of hydrochloric acid used for titration	During all the trials, 20 cm ³ of 0.01 moles of hydrochloric acid was used.
	Mass of vegetable/fruit and volume of water	50g of the fruit/vegetable and 100cm ³ of water was used.
	Mass of antacid and volume of water	2.25g of the crushed antacid and 100cm ³ of water was used.

⁸Gastroesophageal Reflux Disease (GERD): A Review of Conventional And Alternative Treatments. 1st ed. Web. 17 Jan. 2017.

⁹Brown, Catrin and Mike Ford. *Chemistry*. 1st ed. Harlow, Essex: Pearson Education Limited, 2014. Print.

¹⁰Brown, Catrin and Mike Ford. *Chemistry*. 1st ed. Harlow, Essex: Pearson Education Limited, 2014. Print.

¹¹Brown, Catrin and Mike Ford. *Chemistry*. 1st ed. Harlow, Essex: Pearson Education Limited, 2014. Print.

Table 1: Contd.,		
Independent	Volume of fruit/vegetable juice and antacid solution required to neutralize the acid	The amount of juice and solution required to neutralize the hydrochloric acid
Dependent	The alkalinity of the fruit/vegetable juice and antacid solution	The volume of juice and solution required to neutralize the hydrochloric acid was dependent on the alkalinity of the fruit/vegetable and antacid

Preliminary Work

Start Point: In a small beaker, 5cm³ of 0.01 moles of hydrochloric acid was added, with a measuring cylinder. Methyl orange was then added as the indicator so that, the colour of the solution turned red. This was considered as the starting point of the reaction.

End Point: The steps of the 'Start Point' were repeated. After which, one of the natural remedy (*Cucumissativus*) juice was added to the colour of the methyl orange, changed from red to yellow. This was considered the end point of the reaction.

Vegetable and Fruit Selection: Since, a majority of the fruits are acidic, 5 vegetables were initially chosen for this investigation. However, after finding that, Cucumismelo var. Inodorous is an alkaline fruit, it was included as one of the natural fruit remedy in this investigation. Hence, the 4 vegetables and 1 fruit, chosen for this investigation were: Spinaciaoleracea, Brassica oleracea var. italica, Cucumissativus, Momordicacharantia and Cucumismelo var. inodorus.

Preparation of Natural Juices: The fruit/vegetable was chopped (for the *Cucumissativus* juice, the *Cucumissativus* was first peeled and then chopped). 50g of the chopped vegetable was added to the mixer. 100cm³ of water was then added to the mixer. The mixer was switched on for 2 minutes. After this, the juice was removed from the mixer and passed through the sieve 5 times, in order to remove most of the coarse particles present. This was done to prevent any coarse particles, blocking the tip of the burette. This was done thrice so that, at least 250 cm³ of each fruit/vegetable juice was available.

Mass of Vegetable/Fruit and Volume of Water: In order to determine this, trial and error method was used. Determining how much mass of fruit/vegetable, and volume of water was a crucial part of the investigation, since the juice was required to be light in colour (in order to prevent it from overpowering the methyl orange), and thin enough (without any coarse particles) so that, it didn't block the tip of the burette. After 4 trials (100g and 50cm³, 100g and 150cm³, 150g and 150cm³, 50g and 100cm³), 50 grams of the fruit/vegetable and 100cm³ of water gave the desirable liquid.

Preparation of Antacid Solution: 2.25g of the antacid powder was dissolved in 100 cm³ of water. The solution was stirred, until all of the antacid had dissolved in the water. This was repeated thrice so that, at least 250 cm³ of the solution was available

METHODOLOGY AND PROCEDURE

An experiment online determined the titratable acidity of fruit and vegetable products. In this, sodium hydroxide was used to neutralize the acid present in various fruit and vegetable products¹². Since, sodium hydroxide is highly alkaline, phenolphthalein was used as the indicator to determine the equivalence point¹³. A similar approach was taken in

¹² FRUIT AND VEGETABLE PRODUCTS - DETERMINATION OF TITRATABLE ACIDITY. 1st ed. Web. 15 Jan. 2017.

¹³ The point in a reaction where the concentration of the titrant equals to the concentration of the analyte

this investigation, but alkaline fruit and vegetable juices were used to neutralize hydrochloric acid. The effectiveness of these fruit and vegetable juices, was compared against the neutralizing ability of an antacid solution. The volume and concentration of the hydrochloric were constant for all trials, for fairness of results. The juice or solution that required the lowest volume would be most effective.

Since sharp objects and corrosive chemicals, such as a knife and hydrochloric acid were used in the investigation, a pair of gloves and a lab coat was used at times, during the experimental procedure. After the investigation, the remaining acid was neutralized with sodium hydroxide, and then safely disposed to prevent any harm to the environment.

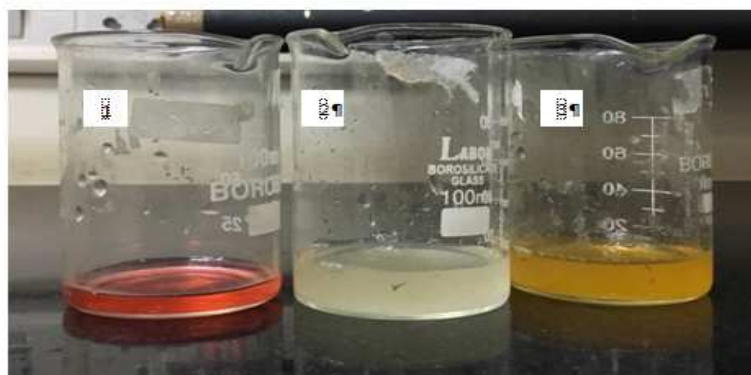
The experimental procedure is presented in the Appendix¹⁴

Modifications in the Experimental Procedure

Since, the colour of the *Cucumissativus* and *Cucumismelo var. inodorus* juices were light, they did not over power the methyl orange. Although, since the natural shade of *Spinaciaoleracea*, *Brassicaoleracea var. italica* and *Momordicacharantia*s were dark green, the juice obtained from these vegetables overpowered the methyl orange. In order to lighten the colour, these juices were then diluted with extra water. Since, 100cm³ of water was used to make all juices, the 3 juices were diluted with multiples of 100cm³ of water, using the measuring cylinder. For these 3 juices, the actual volume required to neutralize the hydrochloric acid was then calculated.

Table 2: The above Table Shows How Much Water was required For the Dilution of Each Fruit and Vegetable

Fruit/Vegetable	Extra Volume of Water Required for Dilution ($\pm 1.00 \text{ cm}^3$)
<i>Cucumismelo var. inodorus</i>	0.00
<i>Cucumissativus</i>	0.00
<i>Momordicacharantia</i>	300.00
<i>Brassicaoleracea var. italica</i>	200.00
<i>Spinaciaoleracea</i>	400.00



1. This Beaker Contains 5cm³ of Hydrochloric Acid with A Few Drops of Methyl Orange (Start Point). 2. This Beaker Contains Hydrochloric Acid and Cucumis Sativus Juice (In Excess). 3. The Beaker Contains Hydrochloric Acid and Cucumis Sativus Juice Along with A Few Drops of Methyl Orange (at Neutralization Point)

Photo 1: The Results for One of the Trials for Cucumis Sativus

¹⁴ Refer to Appendix D

The Data Table for the fruit/vegetable juices is present in the Appendix (Raw Data Table 1)¹⁵

Qualitative Analysis for Fruit and Vegetables:

Cucumissativus: Since, they are naturally light in color, this vegetable juice did not require extra water for dilution. This color was translucent with a tinge of green. The color change of methyl orange was distinct for these 5 trials. After the methyl orange changed its color to orange, one drop of the juice was added to the solution, that changed to yellow.

Brassicaoleracea Var. Italic: This vegetable required 200cm³ of water for dilution. After this, a translucent green solution was produced. The juice was added to the methyl orange, which changed color from red to dark orange. This was continued until the color of the methyl orange changed from dark orange to ochre yellow.

Spinaciaoleracea: This vegetable required the most volume of water, for dilution. After dilution, the green translucent solution was produced. During titration, the methyl orange changed color from red to dark orange (nearing the neutralization point), and then finally to a dark shade of yellow, which signified the neutralization point.

Momordicacharantia: The trials of *Momordicacharantia* were similar to those of spinach and broccoli. When the solution in the conical flask was nearing the neutralization point, the methyl orange changed color from red to a dark shade of orange. When the neutralization point was reached, the methyl orange changed its color from dark orange to ochre yellow.

Cucumismelo Var. Inodorus: The trials for this fruit were similar to those of *Cucumissativus*, since honeydew melon also have a very light color. Hence, it did not require extra water for lightening its color. When a distinctive color change from red to orange, to bright yellow was noticed, the burette was closed.

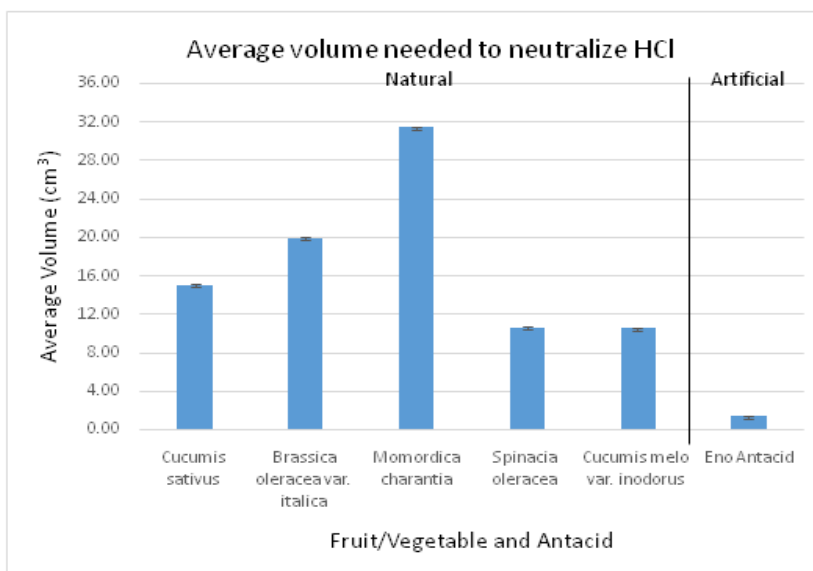
The Data table for the antacid solution is presented in the Appendix (Raw Data Table 2)¹⁶

Qualitative Analysis for Antacid

Eno[™] antacid is a white a powder. When dissolved in water, it formed the cloudy solution. This solution was a light in shade and hence, did not require water for dilution as in the case of broccoli, spinach and bitter gourd. The color change of the methyl orange for these 5 trials was quite prominent and clear. A few of drops of the solution were added at a time, until the methyl orange changed color from red to orange. Once this orange color was achieved, one drop of the solution was added to the methyl orange, that slowly changed its color from light orange to bright yellow.

¹⁵ Refer to Appendix B

¹⁶ Refer to Appendix B



Graph 1: Above is the Graph That Shows the Average Volume of Juice Required to Neutralize the Hydrochloric Acid

Since the vertical error was really small, it was considered negligible and was not taken into consideration, for the rest of the graph.

DATA PROCESSING

Although, it cannot be seen from the graph, the least amount of juice required to neutralize the hydrochloric acid was *Cucumismelo var. inodorus*. However, the average volume of the juices, required to neutralize the hydrochloric acid also takes into account, the extra volume of water required to dilute the *Brassicaoleracea var. Italic*, *Momordicacharantia* and *Spinaciaoleracea* juices. As a result, the actual volume needed to neutralize the acid must be calculated, in order to get a fair comparison. For *Cucumissativus* and *Cucumismelo var. inodorus*, the average volume is the same as the actual volume, because extra water for dilution wasn't required for these two cases. The following calculations show the actual volume, that would be needed to neutralize the 20cm³ of hydrochloric acid:

Brassicaoleracea Var. Italica

Original volume of water required to make juice = 100 cm³

Additional water required for dilution = 200 cm³

Total water = 100 + 200 = 300 cm³

Average volume of *Brassicaoleracea var. italic* juice required = 19.88 cm³

The actual volume of juice required:

$$= \frac{1}{3} \times \text{Average Volume of juice}$$

$$= \frac{1}{3} \times 19.88 \text{ cm}^3$$

$$= 6.63 \text{ cm}^3$$

Momordicacharantia

Original volume of water required to make juice = 100 cm^3

Additional water required for dilution = 300 cm^3

Total water = $100 + 200 = 400 \text{ cm}^3$

Average volume of *Momordicacharantia* juice required = 31.44 cm^3

Actual volume of juice required:

$$= \frac{1}{4} \times \text{Average Volume of juice}$$

$$= \frac{1}{4} \times 31.44 \text{ cm}^3$$

$$= 7.86 \text{ cm}^3$$

Spinaciaoleracea:

Original volume of water required to make juice = 100 cm^3

Additional water required for dilution = 400 cm^3

Total water = $100 + 400 = 500 \text{ cm}^3$

Average volume of *Spinaciaoleracea* juice required = 31.44 cm^3

Actual volume of juice required:

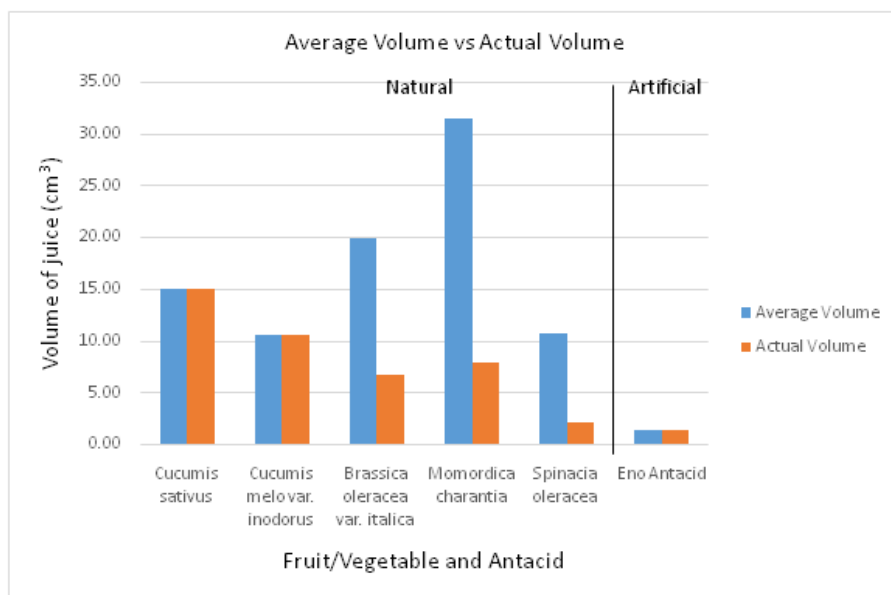
$$= \frac{1}{5} \times \text{Average Volume of juice}$$

$$= \frac{1}{5} \times 10.62 \text{ cm}^3$$

$$= 2.12 \text{ cm}^3$$

Table 3: Above is the Data Table that Shows the Difference between the Average Volumes Needed to Neutralize the Hydrochloric Acid and the Actual Volume Needed to Neutralize the Hydrochloric Acid

Fruit/Vegetable	Average Volume(cm^3)	Actual Volume(cm^3)	Difference(cm^3)
<i>Cucumissativus</i>	15.00	15.00	0.00
<i>Cucumismelo var. inodorus</i>	10.54	10.54	0.00
<i>Brassicaoleracea var. italica</i>	19.88	6.63	13.25
<i>Momordicacharantia</i>	31.44	7.86	23.58
<i>Spinaciaoleracea</i>	10.62	2.12	8.50
Eno Antacid	1.32	1.32	0.00



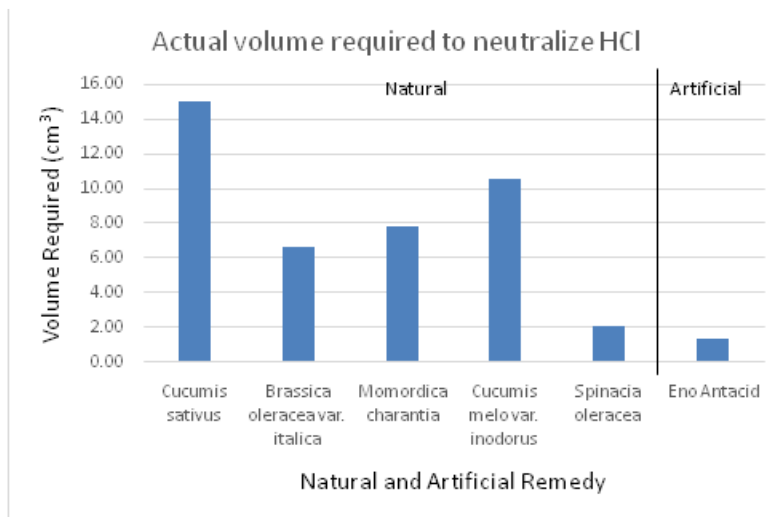
Graph 1: Above is the Graph for the Analyzed Data Table that Shows the Average Volume and Actual Volume for Each Fruit/Vegetable and Antacid

From the analyzed data table and the above graph, it can be seen that, the antacid was the most alkaline natural remedy and hence, more effective at neutralizing excess hydrochloric acid. Amongst the fruit and vegetables, *Spinaciaoleracea* was most effective, at neutralizing the hydrochloric acid. A reason for *Spinaciaoleracea*, being quite effective at neutralizing the hydrochloric acid is *Spinaciaoleracea*'s, chlorophyll content. *Spinaciaoleracea*, being a green leafy vegetable, has a high content of chlorophyll. It contains large amounts of magnesium, that has a large alkalizing effect on the body¹⁷.

Table 4: Above is the Table which shows the Actual Volume of the Natural Juices and Antacid Solution Required to Neutralize the Same Volume and Concentration of Hydrochloric Acid

Remedy	Actual Volume Required to Neutralize HCl (cm ³)
<i>Cucumissativus</i>	15.00
<i>Brassicaoleracea var. italica</i>	6.63
<i>Momordicacharantia</i>	7.86
<i>Cucumismelo var. inodorus</i>	10.54
<i>Spinaciaoleracea</i>	2.12
Eno Antacid	1.32

¹⁷appiah, robert. "Why Take Chlorophyll - Why ALKALIZE YOUR BODY?".*Takebackyourhealthgh.blogspot.in*. Web. 17 Jan. 2017.



Graph 2: The above Graph Shows that Actual Volume of Each Remedy Required to Neutralize the Hydrochloric Acid

When comparing spinach and the antacid, through the graph and data table, it can be seen that, spinach required only 0.80 cm³ of more juice, in order to neutralize the same volume and concentration of hydrochloric acid.

These values are for the remedies, required to neutralize 20cm³ of hydrochloric acid. However, during hyperacidity, large amounts of hydrochloric acid are secreted by the stomach cells. The parietal cells, secrete excess hydrochloric acid, after consumption of an unhealthy meal. During this period, around 250cm³ of hydrochloric acid is secreted by the stomach. In order to neutralize such a large volume of acid, the calculated actual volume would need to be multiplied by the ratio of:

$$\frac{\text{Volume of HCl in stomach}}{\text{Volume of HCl used for experimentation}} = \frac{250}{20} = 12.5$$

Below are the calculations, which show how much *Spinaciaoleracea* juice and an antacid solution would be required, to neutralize 250cm³ of acid in the stomach:

Spinaciaoleracea:

$$\begin{aligned} &= \text{Actual volume required} \times \text{Calculated ratio} \\ &= 2.12 \times 12.5 \\ &= 26.50 \text{ cm}^3 \end{aligned}$$

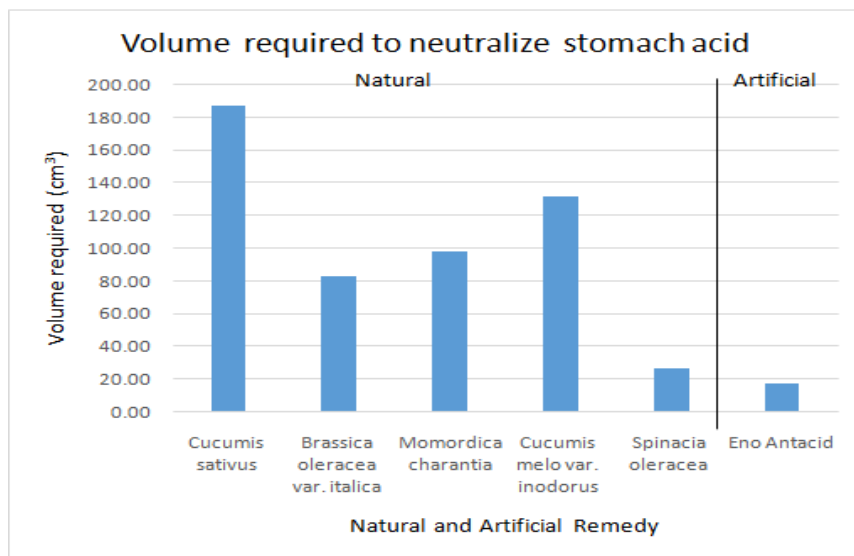
Eno Antacid:

$$\begin{aligned} &= \text{Actual volume required} \times \text{Calculated ratio} \\ &= 1.32 \times 12.5 \\ &= 16.50 \text{ cm}^3 \end{aligned}$$

Similarly, the rest of the calculations were done, for the remaining natural remedies and below are the results:

Table 5

Remedy	Volume Required to Neutralize Actual Stomach Acid (cm ³)
<i>Cucumissativus</i>	187.50
<i>Brassicaoleracea</i> var. <i>italica</i>	82.90
<i>Momordicacharantia</i>	98.30
<i>Cucumismelo</i> var. <i>inodorus</i>	131.80
<i>Spinaciaoleracea</i>	26.50
Eno Antacid	16.50



Graph 3: The above Graph Shows How Much Volume of Each Remedy would be required to Neutralize the Volume of Acid Present in the Stomach during Hyperacidity

From the graph and data table, it is clear that, the antacid was most effective at neutralizing the hydrochloric acid and hence, artificial medicinal antacids are better for curing hyperacidity. Since, the antacid is in the form of a hydrolyzed salt, it is easy for it to split into cations and anions, once dissolved in the water $\longrightarrow [\text{NaHCO}_3 + \text{H}_2\text{O} \text{Na}^+ + \text{OH}^- + \text{H}_2\text{O} + \text{CO}_2]$.¹⁸ This proves my hypothesis right. However, in terms of natural remedies, *Spinaciaoleracea* was most effective, at neutralizing the acid. Only 10cm³ of more *Spinaciaoleracea* juice would be required, to neutralize the stomach acid, as compared to the antacid. With this, it can be said that, *Spinaciaoleracea* can be a close substitute for medicinal antacids. *Spinaciaoleracea*, being a green leaf vegetable, has been benefits whereas antacids, being chemically made, can have certain side effects on the human body.

The main active ingredient of the antacid is sodium bicarbonate. If this is consumed in high doses, or on a frequent basis, it can cause nausea. In worst cases, people can suffer from hyperventilation, heart failure, etc. *Spinaciaoleracea*, on the other hand, doesn't have any drawbacks and only offers benefits to the human body. Since, the difference in volume required to neutralize the acid between spinach and antacid, is only 10 cm³, *Spinaciaoleracea* (juice) can also be considered, as an alternative to consuming antacids, while attempting to cure hyperacidity and reducing acid reflux.

¹⁸ "What Are The Products Of The Dissociation Of Nahco3 In Water? What Is The Relative Ph Of The Solution?".*Chemistry.stackexchange.com*. Web. 17 Jan. 2017.

CONCLUSIONS

After this investigation, it was clear that, what is more effective at neutralizing excess stomach acid, during hyperacidity. EnoTM, being an artificial hydrolyzed salt, was more effective, at neutralizing the hydrochloric acid as compared to the natural remedies. With these results, I was able to answer my research question and prove my hypothesis right. However, from the results of this investigation, it can be concluded that, *Spinaciaoleracea* (spinach) can be a close substitute to any antacid. When it came to neutralizing 20 cm³ of hydrochloric acid, the antacid required 1.32 cm³ of its solution, whereas, spinach required 2.12 cm³ of its juice. This difference of 0.8 cm³ shows the highly alkalinizing properties of *Spinaciaoleracea* (spinach), as a natural remedy for hyperacidity. If consumed regularly, *Spinaciaoleracea* (spinach) would only have positive impacts on the human body (e.g.: lowers cancer risk, lowers blood pressure, improves bone health, etc.). Although, the antacid is more effective than *Spinaciaoleracea* (spinach), at curing stomach acid, frequent consumption of antacids can have side effects that can be harmful in the long run. It is known to cause nausea and bloating in many individuals¹⁹.

When an individual suffers from acid reflux, that person is usually prescribed antacid, due to its convenience and immediate results. However, with the results of this investigation, natural remedies such as *Spinaciaoleracea* (spinach) juice can be prescribed, instead of the different types of antacids for hyperacidity. Compared to an antacid solution, more amount of *Spinaciaoleracea* (spinach) juice would be required, to give the same effect. However, taking the juice would have no side effects, on the body.

Evaluation:

Eventhough, the results were obtained and the research question was answered, there were a number of limitations to this investigation. Below are some of the limitations of this investigation, and the improvements for these limitations:

Limitations:

- When the antacid was added to the water, carbon dioxide bubbles formed and some of these bubbles dissolved in the water, to form some carbonic acid. This must have slightly altered the overall pH of the solution, and must have affected the overall results, since a low concentration of hydrochloric acid was used.
- For *Spinaciaoleracea*, the chlorophyll content diminishes with time²⁰. For this investigation, fresh *Spinaciaoleracea* wasn't used, that would have maximum chlorophyll content, hence, adding some inaccuracy to the investigation.
- EnoTM was found to be more effective, at neutralizing stomach acid. However, these results can't be used to generalize the effectiveness of antacids. This is because, only 5 natural remedies were used to compare, against the effectiveness of antacids.
- After each trial, the apparatus (burette, conical flask and beakers) was washed with water, and then the next trial was carried out. After each wash, some amount of water was left in this apparatus. Since a low concentration of

¹⁹ "Sodium Bicarbonate Side Effects And Contraindications". *Dr. Sircus*. N.p., 2010. Web. 17 Jan. 2017.

²⁰ Cran, D. G. and J. V. Possingham. "The Effect Of Cell Age On Chloroplast Structure And Chlorophyll In Cultured Spinach Leaf Discs". *link.springer.com*. Web. 17 Jan. 2017.

hydrochloric acid, was used for this investigation (0.01 moles), this water left in the apparatus could have affected the overall concentration of the hydrochloric acid, for each trial and hence, caused inaccuracy in recording the volume of juice/ solution, required to neutralize the acid.

- The values calculated in this investigation (Volume of juice/solution required to neutralize actual stomach acid), are not completely accurate. This is because, the volume and concentration of the hydrochloric acid, in the stomach fluctuates depending on various factors. The calculated values just give a rough estimate of how much natural juice/antacid solution, would be required to neutralize around 250 cm³ of 0.01 moles of hydrochloric acid, in the stomach.

Improvements

- After adding the antacid to the water, the water (antacid solution) could have been heated with a Bunsen Burner. This would have driven away the carbon dioxide, and prevented it from dissolving in the water.
- Fresh leaves of *Spinaciaoleracea* could have been used for this investigation, which would have comparatively higher chlorophyll content.
- A larger variety of natural fruits and vegetables could have been chosen for this investigation. With this, there could have been a better chance of determining, if artificial medicinal antacids or natural fruits and vegetables are more effective, at neutralizing excess stomach acid, during hyperacidity.
- In order to prevent unwanted water, affecting the concentration of the hydrochloric acid and the juices/solution, the apparatus could have been dried, after each wash.

REFERENCES

1. Cran, D. G. and J. V. Possingham. "The Effect Of Cell Age On Chloroplast Structure And Chlorophyll In Cultured Spinach Leaf Discs". link.springer.com. Web. 17 Jan. 2017.
2. appiah, robert. "Why Take Chlorophyll - Why ALKALIZE YOUR BODY?". Takebackyourhealthgh.blogspot.in. Web. 17 Jan. 2017.
3. LD, Megan. "Spinach: Health Benefits, Uses, Precautions". *Medical News Today*. Web. 17 Jan. 2017.
4. "Indian Pharma Industry: Market Size, Investment, Sector Growth Report". Ibef.org. Web. 17 Jan. 2017.
5. "What Are The Products Of The Dissociation Of Nahco₃ In Water? What Is The Relative Ph Of The Solution?". Chemistry.stackexchange.com. Web. 17 Jan. 2017.
6. "What Is The Correlation Between Gastric Secretory Volume And Reflux Frequency?". *Hon.ch*. N.p., 1998. Web. 17 Jan. 2017.
7. "Sodium Bicarbonate Side Effects And Contraindications". *Dr. Sircus*. N.p., 2010. Web. 17 Jan. 2017.
8. "The 7 Most Alkaline Foods - Live Energized". *Live Energized*. Web. 15 Jan. 2017.
9. "What Is The Hydrogen Ion Concentration Of Stomach Acid (Ph=2)?". Answers.yahoo.com. Web. 15 Jan. 2017.
10. Helbig,. "Testing Antacids Lab (Autosaved)". Slideshare.net. N.p., 2010. Web. 15 Jan. 2017.
11. "Nonprescription Medicines and Products-Antacids and Acid Reducers". *WebMD*. Web. 15 Jan. 2017.
12. Brennan, John. "Average Amount of Stomach Acid in The Human Stomach". *LIVESTRONG.COM*. Web. 15 Jan. 2017.

13. MacGill, Markus. "What Is Heartburn? What Causes Heartburn?". *Medical News Today*. Web. 15 Jan. 2017.
14. "How To Cure Hyperacidity Naturally". *wikiHow*. Web. 15 Jan. 2017.
15. "Acidity". *The Health Site*. Web. 15 Jan. 2017.
16. "Hyperacidity Treatment, Diet & Causes". *Ayushveda.com*. Web. 15 Jan. 2017.
17. "Stomach Acid Test: Medlineplus Medical Encyclopedia". *Medlineplus.gov*. Web. 18 Jan. 2017.
18. Brown, Catrin and Mike Ford. *Chemistry*. 1st ed. Harlow, Essex: Pearson Education Limited, 2014. Print.
19. *Gastroesophageal Reflux Disease (GERD): A Review Of Conventional And Alternative Treatments*. 1st ed. Web. 17 Jan. 2017.
20. *FRUIT AND VEGETABLE PRODUCTS - DETERMINATION OF TITRATABLE ACIDITY*. 1st ed. Web. 15 Jan. 2017.
21. *Acid Reflux*. 1st ed. Google. Web. 15 Jan. 2017.

APPENDICES

Appendix A: Methodology Evidence



Photo 2: Above is a Photo of the Set up Diagram Before the Burette was Filled with the Natural juice. In the Conical Flask, Hydrochloric Acid was Added along with Methyl Orange. The Small Beaker on the Left Side Was Placed as a Comparison to the Start Point of the Reaction

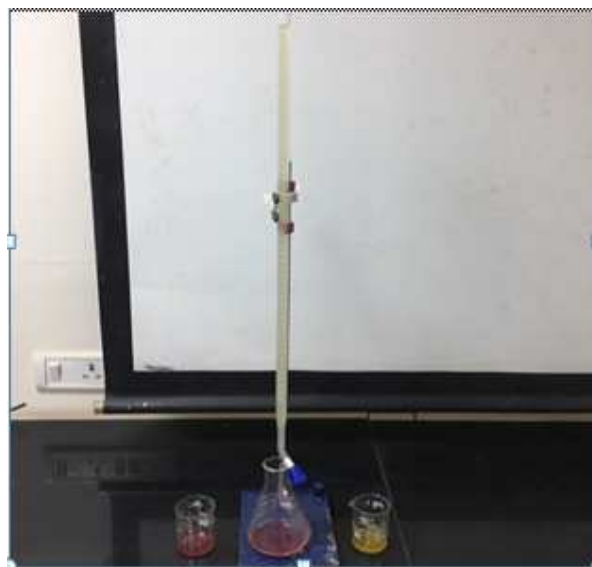


Photo 3: Below is a Photo of the Set Up Diagram after the Burette was Filled with Cucumber Juice. The Small Beaker Place on the Right was Placed as a Comparison to the End Point of the Reaction

Start Point

End Point

Appendix B: Raw Data for Fruit/Vegetable and Antacid

Raw Data Table 1: Volume Required to Neutralize HCl ($\pm 0.05 \text{ cm}^3$) Final Burette Reading (cm^3)

Fruit/Vegetable	Initial Burette Reading (cm^3)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Average Volume (cm^3)
<i>Cucumissativus</i>	0.00	15.00	15.20	15.10	14.80	14.90	15.00
<i>Brassica oleracea</i> var. <i>italica</i>	0.00	20.00	19.70	19.90	20.00	19.80	19.88
<i>Momordicacharantia</i>	0.00	31.60	31.40	31.30	31.40	31.50	31.44
<i>Spinaciaoleracea</i>	0.00	10.80	10.50	10.70	10.60	10.50	10.62
<i>Cucumismelo</i> var. <i>inodorus</i>	0.00	10.50	10.70	10.40	10.60	10.50	10.54

Raw Data Table 2: Volume Required to Neutralize HCl ($\pm 0.05 \text{ cm}^3$) Final Burette Reading (cm^3)

Antacid	Initial Burette Reading (cm^3)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Average Volume (cm^3)
Eno	0.00	1.20	1.50	1.40	1.20	1.30	1.32

Appendix C: Materials and Apparatus

Materials:

- *Spinaciaoleracea*
- *Momordicacharantia*
- *Cucumissativus*
- *Brassica oleracea* var. *italica*
- *Cucumismelo* var. *inodorus*
- EnoTM Antacid (Active Ingredient – Sodium Bicarbonate)

- Hydrochloric Acid ($0.01 \text{ moles per dm}^3$)
- Methyl Orange Indicator
- Water Source



Photo 4: Above is a Photo of the Fruit, Vegetables and Antacid used. They are Arranged in the Following Order from the left: *Spinaciaoleracea*, *Cucumissativus*, *Brassica Oleracea* Var. *Italica*, *Momordicacharantia*, *Cucumismelo* var. *Inodorus* and Eno Antacid

Apparatus:

- Burette x5 ($\pm 0.05 \text{ cm}^3$)
- Burette Stand x5
- Conical Flask x5
- Glass Funnel x5
- 25 ml measuring Cylinder ($\pm 0.50 \text{ cm}^3$)
- 100 ml measuring cylinder ($\pm 1.00 \text{ cm}^3$)
- Mass Balance ($\pm 0.01 \text{ g}$)
- Beakers x2
- Sieve
- Electric Mixer
- Knife
- Peeler
- Stopwatch ($\pm 0.01 \text{ s}$)
- Glass Stirrer

Appendix D: Experimental Procedure

- Attach the burette to the burette stand and insert the glass funnel into the top of the burette.
- Fill up the burette with the fruit/vegetable juice up to the 0.00 cm³ mark.
- With the 25ml measuring cylinder, measure out 20 cm³ of 0.01 moles of hydrochloric acid.
- Add this acid to a clean and dry conical flask and then add 2-3 drops of methyl orange to the conical flask.
- With the glass stirrer, stir the contents of the flask until a red colour is obtained.
- Place the conical flask under the burette and slightly open the stopcock of the burette.
- Add drops of the juice from the burette and swirl the flask simultaneously until a noticeable colour change in the flask is observed.
- When the colour of the contents of the flask turns from red to yellow, close the stopcock and record the volume of juice required to neutralize the hydrochloric acid.
- Repeat this another 4 times for accuracy and reliability of data
- Repeat the above procedure for the remaining natural remedies and then the antacid solution.

